

Why a Metal Rod Gets Hot All Along Its Length



Scenario

You hold one end of a metallic rod. You put the other end in a flame.

Observation

Soon, the end in your bare hand becomes too hot to hold.

The Physics Question

How does the heat travel through solid metal?

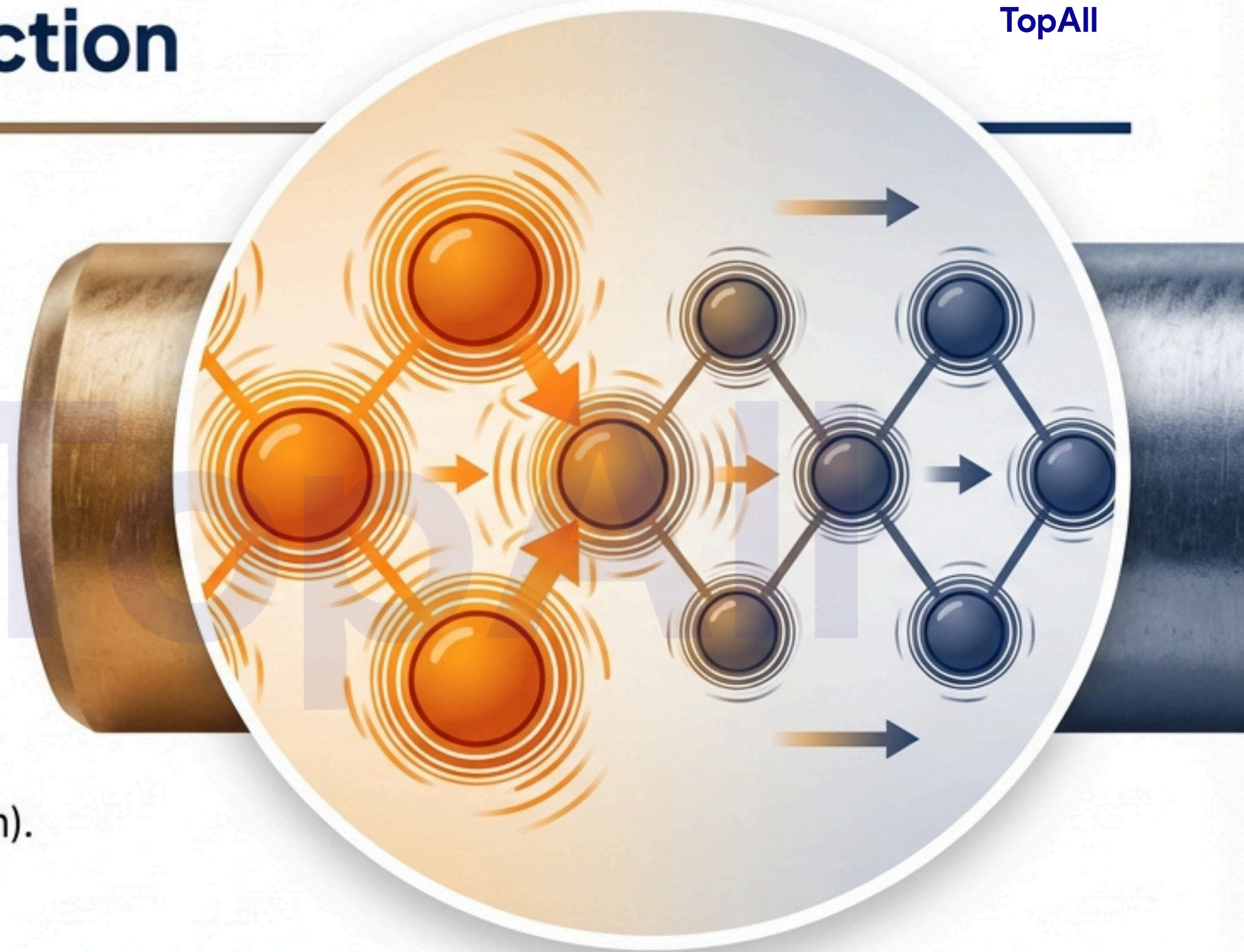
The Mechanism of Conduction

DEFINITION

Conduction is the transfer of heat between two adjacent parts of a body because of their temperature difference.

Key Characteristics

- ➡ - Heat flows from Hot → Cold.
- ↔ - Matter itself does not move (unlike fluid convection).
- ⚡ - Energy is passed along from particle to particle.



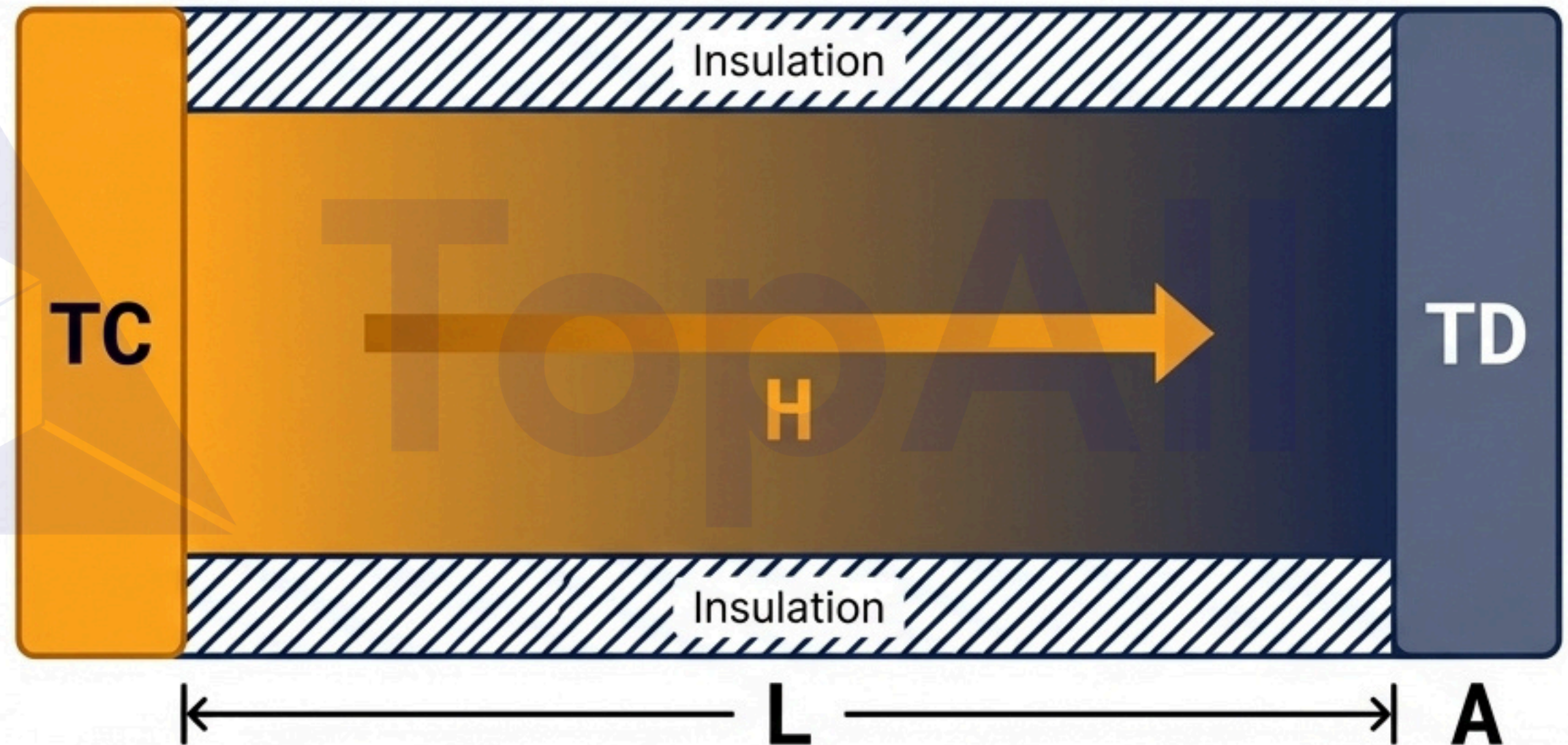
Reaching the “Steady State”

The Setup

- Metallic bar of length L and uniform cross-section A .
- Ends maintained at T_C and T_D ($T_C > T_D$).
- Sides are fully insulated (no heat lost to air).

What is Steady State?

- Temperature decreases uniformly from T_C to T_D .
- Heat entering at C = Heat leaving at D.





The Heat Current Equation

H = Heat Current
(Rate of heat flow)

K = Thermal Conductivity
(Material constant)

A = Area of cross-section

(T_C - T_D) = Temperature difference

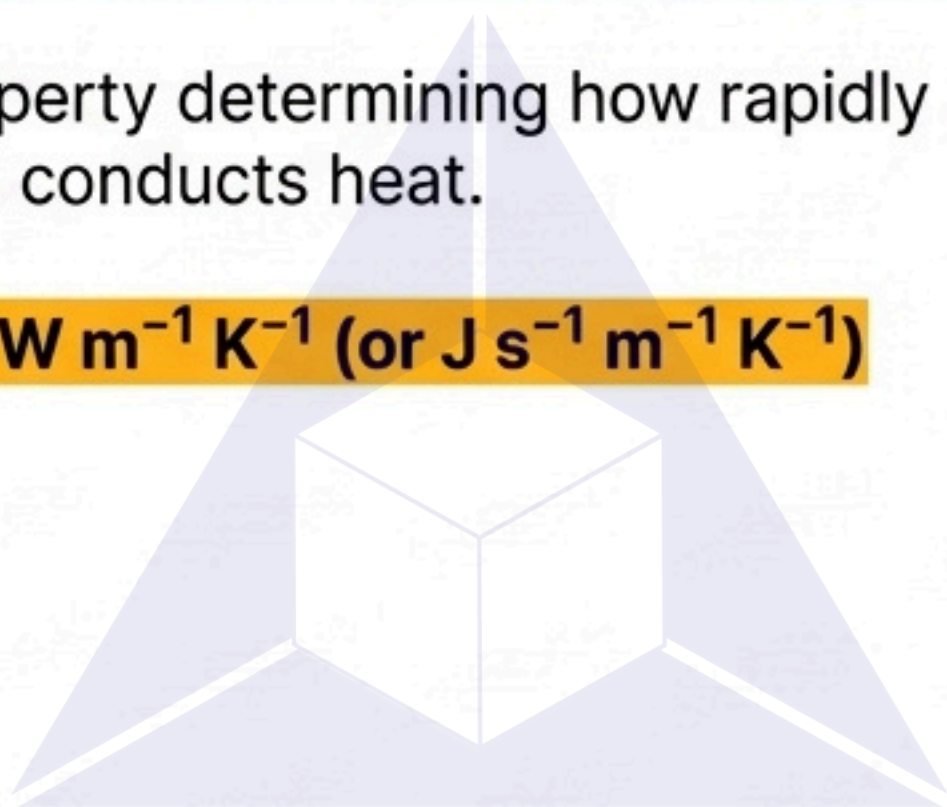
L = Length of the bar

$$H = K \cdot A \cdot \frac{(T_C - T_D)}{L}$$

Cracking Thermal Conductivity (K)

What is K?

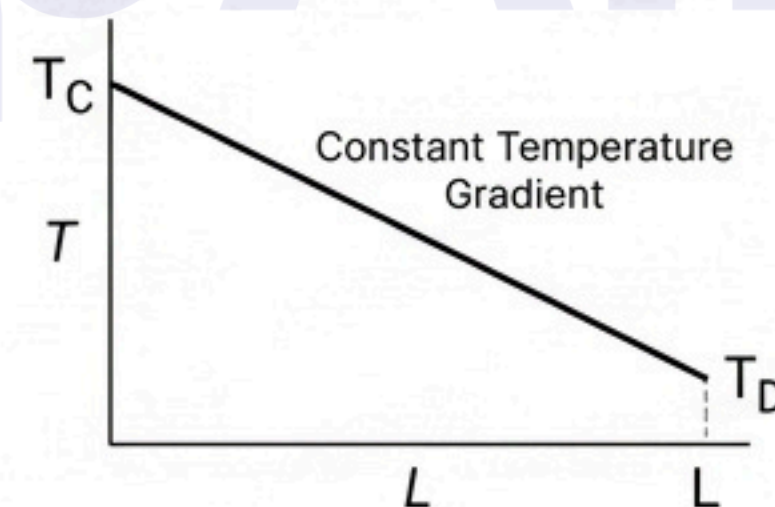
- The property determining how rapidly a material conducts heat.
- **SI Unit: $\text{W m}^{-1} \text{K}^{-1}$ (or $\text{J s}^{-1} \text{m}^{-1} \text{K}^{-1}$)**



EXAM TRAP

Trap: Thinking “Steady State” means the whole rod is the same temperature.

Truth: Steady state means the temperature gradient is locked in. One end is still hot, the other is still cold, but the temperature at any specific spot is no longer changing over time.



Conductors vs. Insulators (Table 10.6)

Good Conductors (High K)

- Silver: **406**
- Copper: **385**



Application Tag
Cookware Bottoms

Poor Conductors / Insulators (Low K)

- Glass: **0.8**
- Wood: **0.12**
- Air: **0.024**



Application Tag
Housing Insulation, Foams

Key Takeaways

- ✓ **The Mechanism:** Conduction transfers heat between adjacent parts via a temperature difference, without bulk material movement.
- ✓ **Steady State:** Reached when the rate of heat flow is constant and the temperature at any point stops changing over time.
- ✓ **The Formula:** Heat current $H = KA(T_C - T_D)/L$.
- ✓ **The K Factor:** High K = Fast conduction (Metals).
Low K = Good insulation (Gases, Foams, Wood).